# THE ZOOLOGIST

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## HABIT-FORMATION IN A WASP (*VESPA* sp.).

By J. M. Dewar, M.D.

The ability of Arthropods to profit by experience is well known. Much, however, remains to be discovered regarding the mechanism and rate of learning. Towards the solution of these problems the present paper is a contribution. Experiments were made, in the month of June, on a queen Wasp* which had her nest in a bank of boulder-clay. Entering the exposed face of the clay through a hollow root, a long tunnel led obliquely backwards and to the right, to end in the wall of a disused rabbit-burrow. The paper nest was affixed to the end of the tunnel, and projected freely into the airway of the rabbit-burrow. The nest was distant about 40 cm. from the plane of entrance to the burrow, and was visible to the human eye at a distance of from three to five metres, according to the intensity of the light. The entrances to the tunnel and the rabbit-burrow were about 50 cm. apart. A nest from the same locality, but well removed from the scene of the observations, contained nothing but eggs and grubs; and such appeared also to be the condition of the nest of the experiments, though it was not opened up to make sure of its state. During the whole period of the observations nothing occurred to raise a doubt as to the identity of the Wasp visiting the nest.

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* Probably *Vespa germanica*, F. The identification rests solely on the markings of the dorsum of the abdomen.

Before the experiments began, a note was made of the general habits. The Wasp always used the tunnel in going to and from the nest. She returned at top speed from the feeding-grounds, and bolted faultlessly into the tunnel, save on rare occasions, when she erred by a few centimetres. The Wasp then hovered for a second or two, at a short distance from the face, until she found the tunnel. Locality studies were not made on departure from the tunnel. The periods of absence ranged from three or four up to twenty minutes.

The method used in the experiments consisted of blocking the entrance to the tunnel with a plug of clay during the absence of the Wasp, and then recording the time elapsing from the moment of the Wasp's arrival in front of the plug until the moment (approximate) she passed through the entrance of the rabbit-burrow at each trial. The times were taken with a stop-watch, excepting at the first three trials. The plug did not prove to be of a very suitable material, the clay crumbling to pieces sooner or later, when a new plug was required. The defect had a real bearing on the results, but nothing else was available at the time. Trials were given on four days within a period of eight days, the last series being a test for retention. It was hoped to form a new habit of going and coming by the rabbit-burrow by retaining the plug constantly in the tunnel, but an hour was lost at the first attempt, while the Wasp, as it subsequently turned out, was engaged in breaking down the plug from the inside of the tunnel. The plug was, therefore, removed from the tunnel at each trial as soon as the Wasp passed into the rabbit-burrow. The Wasp discovered the road to the nest through the rabbit-burrow at the first trial with the plug. At the second trial she succeeded in breaking up the plug, and entered the nest in the normal way by the tunnel. At the third and subsequent trials she was compelled to reach the nest by way of the rabbit-burrow. The times recorded are shown in the table.

The first ten trials were the most interesting of the series, as within them nearly the whole of the learning process was contained. The ten minutes of the first trial were consumed by locality-studies of the immediate neighbourhood of the plug (these studies are here called locality-studies, as they in no way differed from the ordinary locality-study made by the Wasp on

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### LEARNING OF WASP.

(The times are given in seconds.)

| | Days. | | | |
|---|---|---|---|---|
| Trials. | 1. | 3. | 4. | 8. |
| 1 | About 600 | 48 | 3 | 9 |
| 2 | Broke plug | 25 | 22 | 7 |
| 3 | About 240 | 2 | 10 | 27 |
| 4 | 368 | 3 | 2 | 6 |
| 5 | 66 | 15 | 2 | 2 |
| 6 | 26 | 16 | 3 | — |
| 7 | 21 | 10 | 3 | — |
| 8 | 20 | 27 | $\frac{4}{5}$ | — |
| 9 | 7 | 4 | 2 | — |
| 10 | 16 | 9 | $1\frac{1}{5}$ | — |
| 11 | — | 16 | 2 | — |
| 12 | — | 7 | 13 | — |
| 13 | — | $1\frac{2}{5}$ | 36 | — |
| 14 | — | 3 | 7 | — |
| 15 | — | 4 | 2 | — |
| 16 | — | 4 | 5 | — |
| 17 | — | $\frac{4}{5}$ | — | — |
| 18 | — | 10 | — | — |
| 19 | — | 2 | — | — |
| 20 | — | $1\frac{1}{5}$ | — | — |

her departure from the nest), in walking over and digging at the plug, and in high-speed random flights along the face of the clay to right and left for a distance of about 200 cm. each way. At the last of these she passed closely across the entrance to the rabbit-burrow, alighted, and walked in to the nest. In the preceding random movements the Wasp passed the burrow at a distance of about 30 cm., and gave no sign of a positive reaction to the nest. In the random flights of succeeding trials, before the new motor-habit was properly formed, she passed the burrow at a similar distance without giving an obvious sign of reaction to the nest, so that she reacted positively at a distance of 40 to 50 cm., but not at 70 cm., to a nest which was visible to the human eye at a distance of at least 300 cm.

As a result of the first experience, high-speed random flight, or indeed movement of any kind to the left, was eliminated from the succeeding trials, with the exception of the first trial on the third day, when an abortive high-speed random flight of a few centimetres to the left was once observed. High-speed random flights to the right frequently recurred in the subsequent trials. The experience demonstrates the ease with which the Wasp acquired and retained "direction." Not so, however, the formation of the new motor-habit in all its details. Eight more trials were required to bring the new habit towards a fair degree of perfection, and the factors of the learning process were obviously different from the high-speed random flight.

In the third trial (the second was abortive) the Wasp, after hovering before and walking all over the plug, drifted slowly to the right, head-on to the clay face, and alighted to explore every blind pocket in the clay in the plane of the random flights of the first trial. In this way she arrived at and entered the rabbit-burrow. In the following trials she spent less time in examining the plug and gradually reduced the number of blind pockets to be explored on the way, until at the seventh trial the examination of these pockets was entirely eliminated for good. The ninth trial was distinguished by the appearance of a new attitude. While drifting to the right from the plug to the rabbit-burrow, the Wasp no longer squarely faced the clay, but inclined the long axis of the body obliquely to the right, so that the head looked half towards the bank and half towards the rabbit-burrow. In the tenth trial the Wasp, at first, drifted laterally to the right in front of the clay, and then, when half-way, abruptly turned at right angles and flew, head-on, at normal top speed into the rabbit-burrow. The plug was now almost a sufficient stimulus to release the requisite movements leading to the rabbit-burrow, and the sweeping curve of the air-line, followed in all the later trials from the plug into the rabbit-burrow, was well established.

In most of the trials on the third day, a short reaction to the plug induced the quick curving flight into the rabbit-burrow. Several of the trials given on this day showed in the time records apparent lapses on the part of the Wasp. These were due to the necessity of renewing or remodelling the plug of clay used to stop the tunnel. Interference with or renewal of the plug always induced prolonged hovering before and alighting on the plug, with consequently large increases in the recorded times. In the ninth trial the Wasp returned from the feeding-grounds directly to the rabbit-burrow, in front of which she planed to and fro for a few moments. Though in the first trial the Wasp reacted positively to the nest when she was in exactly the same position, on the present occasion she failed to do so, and proceeded to the plug, where she hovered for a little and then flew quickly into the rabbit-burrow. The experience illustrates well the chain-reflex nature of the new habit which had been formed. The movements to be performed in traversing the rabbit-burrow to the nest could not now be released at the entrance to the burrow. The stimulus of the plug was a necessary link in the chain.

The trials given on the fourth day did not differ in general features from those given on the third. At the first and the eleventh trials the Wasp, after hovering before the plug, flew to the entrance of the rabbit-burrow, where she suddenly turned and flew back to the plug. There she hovered again before proceeding finally into the burrow. The twelfth trial was even more remarkable, in that the Wasp returned twice to the plug after reaching the entrance to the burrow. From the notes of these trials it is hard to tell whether the plug failed to give an adequate release of the movement into the burrow, or some new sensation derived from the unsatisfactory material of the plug produced a delayed inhibition of the movement and a compulsory return to the plug.

The trials of the eighth day showed perfect retention after an interval of about ninety hours. Following these retention trials, two returns were observed without the plug having been placed in the tunnel. In the first instance the persistence of habit and an absence of immediate reaction to the actual environment were demonstrated. The Wasp hovered before the tunnel as if the plug were still there. But at the second trial she came in at top speed and dived abruptly into the tunnel.

On leaving the nest the Wasp made locality-studies before the mouth of the tunnel after the first sixteen trials. Thereafter, no locality-studies occurred unless the plug had to be changed or remodelled. Whenever this was the case, the Wasp made a study of the locality. In the last two experiences of the eighth day, without the use of the plug, the Wasp did not make locality-studies after leaving the nest. A prolonged hovering in front of the plug on arrival was correlated with an elaborate locality-study on departure.

Lubbock made similar experiments on Wasps. He fed the Wasps in a room, the nest being outside. The room had two windows, one nearer the nest being closed and the other open. A Wasp, probably a worker *Vespa germanica*, in going home went at first to the closed window. In the first three trials the Wasp had to be " put through the act " by being taken from the closed window and put out by the open window. In the fourth, fifth, and sixth trials it went first to the closed window, then out by the open window. In the seventh to the twenty-second trials the Wasp went directly to the open window. Another Wasp learned the way in a single day and was given fifty trials in five hours. Yet on the next day it went repeatedly to the closed window. Lastly, a worker, probably *Vespa vulgaris*, learned the correct road in five trials, and was given twenty-five trials altogether. The next day it was not so sure of the way, going to the closed window over and over again.*

The experiments, apparently the only ones of the kind that have been applied to Wasps, show for the workers used by Lubbock a slower rate of learning than that of the queen Wasp of the experiments described in the present paper, and the results for retention are much inferior. These differences may, in part at least, be accounted for by the necessity in Lubbock's experiments of breaking up the strong innate tendency of the Wasp to go towards the light, and by preference the lighted area nearer to its nest when a choice of two lighted areas, one near the nest and the other far from the nest, is exhibited. The difficulty was even more marked in the case of a Bee which was admitted by Lubbock to a room through a door at the back of the hive for the purpose of being fed, and which had great difficulty in finding its way back through the postern door of the hive. Here a tendency to go away from the light had to be established, and there was still considerable difficulty at the ninth trial.† The experiments on the queen Wasp were conducted in the open air, the lighting conditions remained unaltered, and the instinctive modes of response to specific sensory stimuli were not affected.

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* Lubbock, 'Ants, Bees, and Wasps,' p. 415 *et seq.*, 9th Ed., 1888. Also a *résumé* in Romanes, 'Animal Intelligence,' p. 145 *et seq.*

† Lubbock, *loc. cit.* p. 274. Romanes, *loc. cit.*, p. 181.

It is hardly worth while attempting to draw any conclusions from a curve of learning based on the reaction times. The learning curve shows the usual rapid initial descent and subsequent irregularities, the most of which may readily be explained as being due to the variable nature of the plug used to close the entrance of the burrow. The method of learning was obviously trial and error or, as some prefer it, trial and success. When the normal sequence of motor activities was interrupted by the presence of the plug, the motor energy of the Wasp liberated itself in random movements which were of two kinds, each kind having a different result. The assumption could not, however, be justified that the two modes of response always function differently in the Wasp. In the present instance the distinctive ends of the two types of movement were clearly the result of accident. The high-speed random flights produced no more than the proper direction by means of an accidental success. The slow exploratory random movements gave position, and eventually, by the elimination of useless movements, established an habitual air-line from the plug to the nest. The Wasp had the power to modify its behaviour in a regulatory way, and she had retention. The Wasp had associative memory as defined by Loeb,* and intelligence according to the definition of Jennings.† The Wasp was able to form an association of a simple kind. She did not connect an old motor-habit with a new sensory stimulus, but formed a new motor-habit in response to a new sensory stimulus. Strictly, one may doubt whether an association was formed at all. There is a difference between the association of a particular movement with a given sensory stimulus and the release of a random, though successful, movement by an adequate sensory cue. The former suggests activity; the latter passiveness. The former has an imaginal or perceptual implication; the latter is purely physiological and explicit. The evidence is altogether in favour of the sufficiency of the second explanation to account for the reactions of the Wasp under trial. The connection between sensation and response was immediate. There was no delay. The accidental success of the first trial did not establish a new road to the nest. In other respects, such as the slow elimination of useless movements, especially in the beginning of each reaction, the results do not favour the presence of images nor ideas, nor even of the sensory thought described by Hunter.* There was evidently sensation, but not perception. Hence the word retention† is to be preferred to the word memory as a term for the mechanism of the more or less permanent modifications of behaviour in the Wasp. The conclusion is reached that the learning of the Wasp did not transcend the sensori-motor level, and that images or ideas were not elements essential to an explanation of the observed reactions.

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* Loeb, 'Comparative Physiology of the Brain,' p. 213, 1900.

† Jennings, 'Behaviour of the Lower Organisms,' p. 333 *et seq.*, 1906.

From the absence of locality-studies prior to the start of the experiments, the discontinuance of the studies after the plug was left out of the tunnel, and their cessation after the sixteenth trial excepting when the plug had to be renewed or remodelled, from the similarity of the behaviour in front of the plug on arrival from the feeding grounds, and the locality studies made before the tunnel on departure from the nest, it may be surmised that the locality study is a compulsory reaction to more or less novel environmental stimuli, having a biological significance to the Wasp, rather than a means directed towards securing an accurate return to the point of departure. The locality-study is certainly a feature of Aculeate behaviour deserving of a far more critical examination than any the study has hitherto received.

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* Hunter, "The Delayed Reaction in Animals and Children," 'Behaviour Monographs,' vol. 2, No. 1, 1913.

† Watson, 'Behaviour,' p. 241, 1914.

# ON THE EDUCABILITY OF THREE ROCKLINGS AND A SEA-BULLHEAD.

### By H. N. Milligan.

Precise notes are rarely made upon the behaviour of common sea-shore fishes during the first few days of their residence in aquaria, or upon the length of time which may elapse before they begin to look for and to accept food from their owner. Such detailed records (not general statements, which are nearly useless) will be of great value when a sufficient volume of them has been obtained. Attention has already been drawn to this subject in the 'Zoologist' ("Tameness in Several Blennies" and "Tameness in a Sea-Bullhead," 1915, pp. 358–9; "Educability of *Galathea strigosa*, 1916, pp. 297–8), and I should now like to describe additional examples of educability in three individuals of the Five-bearded Rockling (*Motella mustela*) and in a Sea-Bullhead (*Cottus bubalis*). The statements contained in this paper are simply those of fact, and no attempt is made to express opinions. It may also be remarked that all the simple modifications of behaviour observed were such as sprung naturally out of the fishes' new environment, and the animals were not "taught" nor set "tasks" to perform.

(1) On October 9th, 1915, a Rockling of three and a half inches in length, obtained from Weymouth, was placed in an aquarium. The tank contained about twenty-seven gallons of water and a mass of rockwork which provided convenient hiding places for the fish. The Rockling, as is usual with individuals of this species, remained almost motionless and almost completely hidden (during the daytime at least) in recesses of the rocks during the first few days of its captivity. On the morning of October 14th, however, when its head was observed to be projecting slightly from the rocks, the fish was induced to take, apparently without fear, a piece of raw beef from the wooden feeding-forceps. On the morning of the 15th (that is, during the sixth day of captivity), when the fish was lying fully exposed on the rocks, the food-tainted forceps were gently laid against its snout. The fish at once began to examine the forceps, swimming

round and round them and rubbing the snout and fore part of its body upon them, in the characteristically eager manner of a hungry Rockling, which curiously suggests the rubbing of a cat round the leg of a person from whom it wishes for food or caresses. A piece of beef was now presented to the fish, and was eagerly taken. A few minutes later the Rockling was easily induced to follow the forceps to the surface of the water, where it took three successive pieces of beef from my fingers. From then until the death of the Rockling by accident on October 27th it was my daily custom with the forceps to entice the fish to come from its resting place amongst the rocks to the surface of the water to be fed. If my finger was rubbed on raw beef, fish, or mussel, and then placed in the water close to the rockling, the fish would anxiously press the snout and fore part of its body upon the finger, and move round it in the cat-like manner already mentioned.

(2) A Rockling of four and a half inches in length, from Weymouth, was placed in an aquarium on November 9th, 1915. It hid itself completely amongst the rocks until the 15th. On the morning of this day (that is, the sixth day of captivity) when its head could be seen at the entrance to the hole in which it had made its home, it was offered a piece of mussel in the forceps. The Rockling seemed divided between hunger and fear, for it alternately approached close to and retreated from the food several successive times, finally taking alarm and dashing suddenly back into its resting place without eating the food. It continued to behave in this way until the morning of the 25th (the sixteenth day of captivity), when it took three successive pieces of mussel from the forceps, without much fear. By the twentieth day of captivity it had learned to come out of its retreat when the forceps were placed at the entrance. On the morning of December 1st (twenty-second day) a further advance in the education of the Rockling, suspected as early as November 27th (eighteenth day) but now rendered certain, was to be noted. It is necessary to illuminate the aquarium, which is in a shady though not dark place, by an electric lamp suspended over the tank, when the fishes are to be fed. On the morning of the twenty-second day it was observed that the sudden illumination of the tank, followed by movement of the surface of the water as

the forceps were dipped into it, caused the Rockling to dart excitedly out of its hole and swim eagerly about the tank. From that day (on which it first began to feed from my fingers) the illumination of the tank by any visitor who examined it was sufficient, providing the Rockling was not full fed, to bring the fish from its resting place; and this might happen several times in the course of an hour. It responded most certainly, however, to the illumination early in the morning, when it was hungry. By the fortieth day a further advance in the education of the Rockling could definitely be noted. It is my custom to introduce the forceps into the aquarium from one particular corner of the tank. It was now observed that when the fish left its hole to look for food it always travelled (round the walls) towards this corner, where it would swim to and fro, and upwards and downwards, in the water. Indeed, it was often the case that when the aquarium was approached with food in the morning, the Rockling was found to be waiting there. On January 18th, for example, the fish was found at 9.30 a.m. in the corner, moving excitedly to and fro, and it remained there until it was fed at 11.15 a.m., after which it retreated to its hiding place. By January 1st (fifty-third day) it could be noted that the Rockling, affected no doubt by the tranquillity of life in an aquarium in which there were no enemies except tiny Swimming-Crabs and small Opelet Sea-Anemones, displayed little or no alarm when it was given a tap with the forceps; a touch of the forceps during the first fifteen or twenty days of captivity would have caused the fish to dash to its hole; in January if it retreated at all it did so in a leisurely fashion. On January 18th (seventieth day) two Shore-Crabs were placed in the aquarium, but the presence of these fierce crustaceans did not deter the Rockling from waiting for food at the corner of the tank.

(3) A third Rockling, five inches in length, also from Weymouth, was placed along with the second Rockling on December 8th, 1915. It at once darted to the shelter of the rocks. On the morning of the 9th, when it was partly exposed amongst the rocks, it was offered a piece of mussel in the forceps, but this was refused with signs of fear. It was not until the morning of December 18th (tenth day) that it took pieces of mussel from the forceps, but on this day it also followed the

forceps through the water as though seeking for further food. By January 1st (twenty-fourth day) it had become accustomed to taking food from my fingers. On January 6th (twenty-ninth day) it was noted that the Rockling was awaiting food, along with the second Rockling, at the corner of the tank, and it continued to do this. Both Rocklings died in February.

In order that the importance of the foregoing facts may be appreciated it must be observed that the Five-bearded Rockling is an exceedingly timid nocturnal fish which dreads light and light-coloured surfaces. J. Stuart Thomson ("The Dorsal Vibratile Fin of the Rockling (*Motella*)," 'Quart. Journ. Micro. Sci.,' No. 229, vol. 58, N.S., September, 1912, p. 250) mentions that in his observations upon Rocklings it was necessary to keep even the light of a candle in a more or less shaded place.

On December 8th, 1915, a Sea-Bullhead (*Cottus bubalis*) of three and a half inches in length, from Weymouth, was placed in an aquarium which already contained several large individuals of the Goby (*Gobius paganellus*). It should here be remarked that the Sea-Bullhead finds food mainly by the sense of sight, whereas the Rockling finds food by touch, taste, and smell.

The Bullhead was at first very timid, and invariably retreated by swimming heavily and jerkily through the water when the forceps were placed close to its body. The fish lay for the greater part of the time partially embedded in the pebbles of the bottom, or clinging with its spreading pectoral fins to the vertical rockwork at the back of the aquarium. On the morning of December 10th (that is, during the second day of captivity) a piece of mussel, and afterwards a piece of raw beef, was offered to the Bullhead in the forceps, but the fish appeared to take no notice of the food, and swam away when the pieces of beef and mussel were thrown on the bottom close to its head. The Bullhead again refused beef and mussel on the 11th. On the morning of the 17th (ninth day) it took three successive pieces of beef which were thrown into the water, but it would not approach a piece which was held towards it in the forceps. The jerky movements of the Gobies, which are in the habit of darting rapidly out of their holes to seize food and then darting back again, probably added to the Bullhead's fear of the forceps. It was not until December 27th (nineteenth day) that it could definitely be noted that the Bullhead had begun to associate the illumination of the aquarium, and subsequent introduction of the forceps into the water, with the advent of food. On December 28th, when the surface of the water was disturbed with the forceps, the Bullhead looked up with the characteristically scrutinising glance of this species of fish, and then excitedly snapped at fragments of seaweed which were caused to move by the agitated water. On the 31st (twenty-third day) the Bullhead approached, with unmistakable eagerness for food, the glass front of the aquarium, when the electric light was turned on and the glass tapped with the fingers; and then it swam in its usual heavy fashion to the surface of the water as though anticipating the introduction of food there. On January 5th (twenty-eighth day), when the light was turned on, the Bullhead darted to the surface and put its snout out of the water several times. It then retreated to the top of the rockwork, which is four inches from the surface. A finger was put into the water, with its tip just beneath the surface, and the Bullhead made several darts towards it. The fish then received pieces of mussel from my fingers. By this time the Bullhead had apparently lost all fear of human beings, and it seemed to be in no way alarmed—indeed, it scarcely noticed—a gentle thrust from a finger or from the forceps. On the morning of January 11th the fish would not trouble itself to move from a certain place until it had received several thrusts of increasing force from the forceps. On the 15th (thirty-eighth day) it darted to the glass, against which a piece of mussel was held; it then followed the food as it was slowly dragged up the glass to the surface; there the mussel was taken by the fish from my fingers. From about that date onwards, a few taps upon the glass, preceded or not by illumination of the tank, was sufficient to bring the Bullhead, if it had not been fed, eagerly to the front of the aquarium. The fish died in July, but before this time it had become so confident that it was sometimes possible to take it in the fingers for examination, but not, of course, to lift it out of the water.

# HINDU ZOOLOGICAL BELIEFS.

By W. Rae Sherriffs,
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(Concluded from p. 259.)

Birds.—Commonest of all Indian birds is the Crow, which, in Madras, at any rate, is considered to at least equal the human population in number. As everyone knows, this wily bird always looks askance, and the Brahmin Crow (*Corvus splendens*) is thus believed to have only one eyeball, which, however, can move at will into either socket. To account for this remarkable ocular phenomenon the following tale is related:

One day, when Rama and Sita were exiles in the forest, Rama lay asleep with his head on Sita's lap, when a Crow, who was really Indra's son Jayantha, jealous of the sight, came and pecked at Sita's breast till it bled. Sita loved Rama so much that she would not move lest she should wake her lord. Shortly after, a drop of warm blood from the wound fell on Rama's face. He at once woke up, and, recognising the Crow, shot an arrow at him. Off flew the Crow, with the vengeful shaft in full pursuit; and the Crow in despair implored all the deities to save him, but in vain. Back he had to fly to Rama, and humbly ask for pardon, which was readily granted, but on one condition. "My arrow," said Rama, "must find its mark." This it did by removing one of the Crow's eyeballs. Yet for all that, the bird suffers little inconvenience, because the remaining eyeball can shift as required from the one orbit to the other.

The Crow is the vehicle of Saturn, who acts adversely upon everyone's life for a period of seven and a half years. Both these are worshipped by all every Saturday.

If a Crow takes up its position on the roof of your house and caws incessantly, then you know that a guest will arrive soon. In order to ascertain the nature of the expected visitor you say to the Crow, "If it is a friend who is coming to see us, then walk up and down, but if it is only another Crow that is to arrive, then fly away at once." According as the Crow obeys your command, you know whom to await.

The Kite, Garuda (*Haliastur indus*), commonly called the Brahminy Kite because of its white head and neck, carries Vishnu. When you see it or hear it, cry "Krishna," and worship it. To hear its cry, which is a shrill, querulous whistle, is always lucky, and especially so on Sunday mornings.

The Hindu regards as lucky or the opposite many animals, according as you see them to your left or right. If you meet on your left the King-Crow (*Dicrurus*), Brahminy Kite (*Haliastur*), Quail, *Neophron*, Owl, *Varanus*, *Herpestes*, *Simia*, *Astur*, *Xantholæma*, Squirrel, or a Dog, then good will come to you, and *vice versâ*. Certain others—*Ardeola*, *Ceryle*, Crow, Crow-Pheasant, Parrot, Peacock, Common Fowl, *Calotes*, Spotted Deer, Civet Cat, Tiger, Fox, and Buffalo—when met on the right, are always a good omen. Some animals, if they cross your path, always bring bad luck—*cf.* Cat, Snake, Rabbit, or Hare. The following are always good to hear: the screech of the Owl, the squeak of the Shrew, the chanting of the Vedas, the braying of the Ass, the neighing of a Horse, and the flapping of a Dog's ears when it shakes its head; but wailing, the grunting of the Pig, and the crowing of the Cock denote evil.

Birds flying towards you are of good import, and so also is an approaching Cow, Bull, Horse, or Elephant.

The Swan (annam or humsam) is the carrier of Brahma. Long ago Brahma and Vishnu wished to find out which was the superior of them, and Shiva kindly consented and condescended to act as judge. When the two deities were ready for the contest, Shiva suddenly assumed gigantic proportions, his feet resting far below the under-world, while his head overtopped the highest clouds. Whichever of the competitors first discovered Shiva's head or feet was to be adjudged the superior. Vishnu at once assumed the form of a Boar, and began digging into the earth with his tusks in order to get at Shiva's feet. He soon gave up the attempt, but another form of this story asserts that he is digging away yet. Brahma, on the other hand, took the form of his vehicle, the Swan, and flew upwards to locate Shiva's head. As he mounted in the air there fell down a bract of the Screw-Pine (*Pandanus*), which up till then the god had worn round his head.

The Swan seized the bract, and with its consent came to earth, saying that he had found Shiva's head, for was not this very bract proof of that?

This humsam is the Indian emblem of discrimination. Just as this mythical Swan is able to distinguish between water and milk, and select only the milk from the mixture, so is the Indian student frequently exhorted to emulate the bird, and thus be able to discriminate in his studies between what is really of value to him and what will profit him nothing.

The Peacock is the favourite bird of Indra. It bears the god Subrahmanyam, while Saraswati is also depicted as riding upon it. It is the only bird that is said to rejoice at the coming of the rains.

King Sibi was famed for his virtue and charity. The gods resolved to try him. Agni became a Dove, while Indra changed himself into an Eagle. Pursued by the bird of prey, the poor Dove flew in terror to the king and implored his protection, which was at once granted. On hearing this, the Eagle at once protested to the king that he must not be deprived of his food. King Sibi then asked the Eagle to prefer some other request, which he promised to perform faithfully; whereupon the Eagle demanded a weight of the king's own flesh equivalent to that of the Dove, but the sacrifice had to be made willingly. To this atrocious demand the rajah assented. Scales were produced, but always when the king's flesh was just on the point of weighing down the bird, the latter's weight increased, until, when the last morsel was about to be removed from the royal body, Eagle and Dove took their proper forms, revealing themselves to the king, whom they warmly commended for his charity.

Screech-Owls are common in the plains of South India. The frequency of their cry is of great import. Once signifies news of death; twice, success in work; three times, gratification of desires; four times, dissension; five times, travel; six times, visits from a relative; seven times, loss; eight times, immediate news of death; nine times, all that is good; more than nine times, good luck.

The Chuckorah is a mythical bird mentioned in Indian poets. It was said to feed solely on moonbeams.

Jatayus, the king of the Vultures, attacked the ogre Ravana when he carried off Sita. The demon cut off a wing, but the bird lived just long enough to narrate to Rama all that had happened.

At Tiru Kalikundram, the hill of the sacred Vultures, several miles south of Madras, two well-known birds come daily to the temple to be fed at eleven o'clock in the forenoon by the priests. The temple is ancient, and for centuries past these birds (*Neophron*) are popularly believed to be rishis who leave Benares every morning, stay for lunch here, and then haste on to Rameswaram, which they reach at nightfall.

There are many Cuckoos in the plains, but the commonest is the Koel (*Eudynamis*), the call of which resembles the Tamil word "akka" (sister), and the belief is to the effect that a man once had two beautiful daughters, one of whom was accidentally drowned in the sacred Cauvery, and the other changed to this bird, which, when the river is in flood, still calls for her sister.

Mammals.—The white Bull is the steed of Shiva, the Buffalo that of Yama, the god of death. The Cow, of course, is a very sacred animal. It arose first from the milk-ocean and had a woman's face. Every Friday the Cow is worshipped, its body being dotted with red or yellow powder. Kamadhenu is the sacred or wishing Cow, the Cow of plenty, and was won by the sage Vasishta as a reward for his ascetic merit, but in reality it belonged to Indra.

Six men once conspired against the rishi Gautama. At their request Ganesa became an emaciated Cow, which angered the sage so that he struck it with a blade of grass, and to his horror killed the animal. Now, to slay a Brahmin or a Cow is the greatest sin possible for a Hindu, and the sage was plunged in remorse for his deed, but Shiva, knowing the artifice, purified him by pouring on him the waters of the Ganges from his ruddy locks.

The Horse, Uchaisrava, so called from the loudness of his neighings, arose from the churning of the milk-ocean. The sun's chariot is drawn by seven Horses, the seven prismatic colours, and it has only one wheel. Badaba is the Horse believed to live at the bottom of the sea. He bears a light in his forehead, which, at the end of the world, is to burn up everything. The renowned Horse sacrifice (aswamedha) had its origin in this way. King Sagara had sixty thousand sons. He had performed ninety-nine horse sacrifices, and was desirous of completing the hundredth ; but Indra got jealous, because if the king did so, he would be his equal. Indra thereupon stole the Horse selected for this hundredth sacrifice, removed it to the underworld, and there tied it to the back of a rishi, Kapila, who was meditating. The king's sons searched everywhere on earth, but in vain, and soon convinced that the creature was not in the world, they began to dig down for it. When they saw the Horse tied to the sage, they blamed him for stealing it, and he, thus rudely interrupted in his pious meditations, merely opened his eyes on them and the glare reduced them all to ashes.

Many years afterwards, Bagirata, a descendant of King Sagara, learning of the fate of his ancestors and knowing that, since no funeral rites had been performed, their souls had not yet reached heaven, practised austerities and prayed to Brahma that the holy waters of the Ganges might descend and flow over their bones. His request was granted. The Ganges came down with such violence that the earth itself would have been washed away had not Shiva intercepted the flood in his matted hair. Ultimately, Ganga was allowed to flow gently to the lower regions, and whenever its waters covered the ashes of the departed, their souls reached bliss. This tale has given to the river the name Bagirathi.

The Horse Uchaisrava is Indra's steed also. Kalki, the last avatar of Vishnu, is yet to come, on a white Horse, to end the present kaliyuga (age).

The Spotted Deer (*Axis*) is mentioned in the *Ramayana*. When Ravana wished to carry off Sita, he sent his nephew in the form of a beautiful Stag, Maricha, to play before the hermitage, knowing full well that Sita's curiosity would certainly be aroused. As he planned, so everything came to pass. Rama went after the Stag to shoot it. Lakshmana, his brother, soon followed him, leaving alone and unprotected Sita, who was then seized and carried off by Ravana himself. Deer are always mentioned in any description of a forest. They are the type of gentleness and quietness, and for this reason women are compared to them. The chamara is a brush made of white hairs from the Deer's tail, and used to keep flies off the god in the temple.

When sunshine and shower mingle, then the Fox is getting married—others, however, say it is the Tiger—and to see its face in the morning is a good thing.

A bad man may become a Dog in his next birth. When a Dog recollects his previous births, and all he did in them, then it is that he bays, especially on bright moonlight nights. Dogs are said to be able to see Yama, the god of death, and to howl at him.

The Cat is a pet of Sri Krishna, and must not be killed on this account. The Cat, furthermore, is the Tiger's uncle, and taught him everything he knew, save one trick—namely, how to climb trees. One day the two fell out, and the Cat saved its life by climbing a tree, which enraged the Tiger so much that he declared he would go even the length of eating the Cat's excrement, if so he might learn to climb trees. For this reason the Cat is ever so careful to always bury it, and the baffled Tiger is unable to climb yet.

Jambavan is the king of the Bears. Once Brahma happened to yawn rather deeply, when out came this animal, who was sent round the earth to proclaim by "tomtoming" that Vishnu was the lord of the three worlds, at the time when Vishnu was in the avatar of Vamana, the dwarf. Mount Mahameru happened to strike Jambavan on the knee, so to this day all Bears walk slightly lame. When anyone boasted of a great feat, then Jambavan declared that of course he could have done it much better had he not met with this accident which lamed him. "As old as Jambavan" is a Tamil saying.

A white Elephant is the vehicle of Indra, and is called "aira vata."* It arose from the milk-ocean. The Elephant can act as the mount of all the gods, and one is commonly kept in each big temple. In South India it is regarded as being very faithful, but also vindictive. It is believed to be in constant dread of ants entering its ears, and that explains why it is continually flapping them. The Elephant's gait is thought slow and majestic, and it is a compliment if you are said to walk like one. According to one story, eight Elephants stand on a Turtle, supporting this earth of ours, and face the eight chief points of the compass. Ravana once fought with them, and their tusks, breaking off, stuck in his breast, where he decorated them with rubies and diamonds.

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* It is also known as Indravat , and its trunk is the water-spout.

The Elephant god, or belly-god, called Ganesa, Vigneswara. Ganipathi, or Pillayer, is the son of Shiva, and his image is found in every Hindu temple, usually in the south-west wall of the building. Ganesa has only one tusk, because when Vyasa dictated the *Mahabharata* and desired someone to write it down for him, Ganesa volunteered to be scribe, and broke off one tusk for his pen, while for his paper he took the earth. Another version says that he lost his tusk in fighting his brother, Subrahmanyam, the god of war, who defeated him. At any rate, Ganesa is often known as "eka dantha," the one-tusked, on this account.

He is not yet married. His mother brought him several ladies to wife, but he refused them all, saying he would never marry till he found the girl who exactly resembled his mother. He is still looking for her, and his temple being usually at the entrance to every village, he can scan each fresh arrival as she comes forward.

Yali is a mythical animal, much stronger than a Lion, and the vehicle of Kali,* the goddess of destruction, who is not much worshipped in South India, because she requires libations of blood, which are distasteful to Brahmins.

Varaha, the Boar, is the third avatar of Vishnu. One account of this story has already been given, but another reason why Vishnu took this form was to punish two rakshasas named Hiranyaksha and Hiranykasipa, who were his enemies. The former rolled up this world into a mass and threw it into the sea. Thus was the earth lost for the time being. Vishnu, by taking the form of a Boar, dived into the waters, and bore it out again safely on his tusks, after which, in a fight, he slew the demon.

The Boar is not an animal adapted for an aquatic life, but in this case Hiranyaksha, by practising austerities, had obtained from Brahma the double boon of universal sovereignty and of immunity from injury by certain harmful animals, which were enumerated, but unfortunately the Boar was not included in the list.

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* Parvati as Durga or Kali slew Mahisasur, the demon Buffalo, after which the state of Mysore is named.

Narasimha, the fourth avatar of Vishnu, was half man and half lion. On the death of Hiranyaksha, the second demon said that he was the god, and made his subjects worship him and not Vishnu. Notwithstanding his father's commands, the son Prachlada believed in Vishnu, and thus incurred his father's enmity. One day Hiranykasipa challenged his son to prove that Vishnu was the god, and the son replied that Vishnu was everywhere. Then the father in derision asked if he were inside a particular stone pillar near by. On the son saying "Yes," the father got very angry with him, and out of contempt kicked the pillar, from which Vishnu as Narasimha at once burst forth and tore the impious wretch in pieces.

In his early days Hiranykasipa had done penance, and the boon granted him then was that he would not be killed by anything dead or alive, inside or outside his house, by day or by night, by man or by beast, and if a single drop of his blood was spilled, a thousand men as strong as himself would immediately spring forth to his assistance. He was slain by the claws of Vishnu as Narasimha, half man, half lion, on the doorstep of his house at sunset, and Narasimha drank up every drop of blood so that nought was shed. Thus were all the conditions of the boon evaded. To this day, in every Hindu house at sunset, all are asked to be quiet, for at this time Hiranykasipa died, and it is the hour for evening worship.

The common Shrew (*Crocidura cœrulea*), known to the Anglo-Indian as the "musk rat," is the vehicle of Ganesa. Its voice is held to be very auspicious, and it is never killed because it is considered so very harmless.

The Bandicoot Rat is the largest one. "As stout as a Bandicoot" is a familar comparison in South India. The Squirrels took part, along with the Monkeys under Hanuman, in the building of the bridge over to Ceylon. The little Palm-Squirrel (*Funambulus*) is one of the commonest animals. It could not do much to help, but it gathered a little sand on its bushy tail and threw it into the sea. Rama, noticing this act, was very pleased, and in blessing the tiny creature, stroked it with three of his fingers; hence the origin of the three lines down its back to-day. "And the people tell how the little Squirrels helped in the building of the bridge to Lanka, bringing stones and shells and broken nuts to make it smooth. And for this, when the work was done Rama took one of the smallest workmen in his hand, and stroked him, blessing him from head to tail. And because of this blessing of Rama, it is that the Indian Squirrel wears three white stripes on his dark fur; they are the finger-marks of the blessing of the Lord of the Universe."

All Monkeys are sacred because of the monkey-god Hanuman. A maid called Angavadevi was one day doing penance and wishing for a son, when Vayu, the god of wind, visited her and granted her request, Hanuman being born to her. He is the type of strength and energy. Just after he was born he thought the sun was a fruit. It was the day of an eclipse, and the sun was just about to be swallowed by Rahu and Ketu, when Hanuman interfered. Rahu complained to Indra that he was being interrupted in his work by Hanuman. Indra then came with his club in his hand, and struck Hanuman a blow on the cheek, leaving a permanent depression there, which gave him his name, for Hanuman signifies having had something done to the cheek. Vayu, when he saw his son lying senseless, concentrated himself, so that all the atmosphere was withdrawn from the world, to the great dismay and annoyance of all the earth-dwellers, who complained to the great Hindu trinity, imploring them to restore matters. The gods all granted boons to Hanuman when Vayu had dissipated himself once more. Vayu made his son as swift as himself, Agni promised he would never be burnt or destroyed by fire, while Rama said he would withhold his arrow from him.

Wherever and whenever the *Ramayana* is read, there and then Hanuman is the unseen listener present to enjoy the tale. Hanuman is the favourite god of all the Raos and of conjurers. If his worship is not strictly attended to, then swift punishment falls on the offender.

# NOTES ON THE INABILITY OF NATURAL SELECTION TO EXPLAIN CERTAIN STEPS IN THE EVOLUTION OF PROTOZOA.

By R. D. Greenaway.

During the past sixteen years biological study has made very great strides in all directions. Especially is this true in the departments of Heredity and Biogeny. The work of Mendel and De Vries and the teachings of Bergson have revolutionised these branches of biology. Constructive work has gone hand in hand with rigorous criticism of previous theories. Many of the most cherished conceptions of biologists have gone into the Medea's Cauldron of criticism, and not a few have shared the fate of Pelias.

The doctrine of natural selection has not escaped its share of criticism. The conviction, deepening every year, that evolution *has* occurred, has been attended by a growth of scepticism as to whether the theory which up to the end of the nineteenth century was held to have solved the riddle of organic existence really does so. This scepticism is no new thing; witness the objection, still with us (though robbed of much of its force by recent discovery), that incipient stages in the development of really useful structures would be too insignificant to secure survival. But of late three more fundamental difficulties have presented themselves. Firstly, the uselessness of many specific characters; secondly, the discovery of the fact that germinal variations (the only hereditary ones), are not the same as the minute fluctuations in every direction which were formerly believed to be of hereditary value. Finally, it is argued that, since true germinal variation is definite and comparatively infrequent, the development of highly complex organs (like the vertebrate eye) through the selection of random variations (difficult enough to conceive even if given a multiplicity of such variations in every direction) now becomes unthinkable.

It is real difficulties like these which are leading biologists to believe that the part played by natural selection in evolution has been in the past much over-rated; that it acts rather as the pruner of the Tree of Life than as its energy of growth; and that the final cause of evolution lies deeper, in the very nature of life itself; an idea as old as philosophy, and which has been given its latest and most splendid expression in Bergson's doctrine of the *élan vital*, the eternal self-evolving impetus which is Life and Mind.

The present article is an attempt to illustrate, by example taken from the lowest phylum of animals, another difficulty which is, I believe, more novel. This difficulty is, in brief, that while there are many structures whose development is theoretically explainable (frequently easily so) by the theory of natural selection, yet from the nature of present circumstances they cannot have been developed by selection. This idea originally suggested itself to me while engaged in the study of the Protozoa, and I have subsequently spent some time in its elaboration. The main conclusions which I have reached are outlined in the following pages.

## 1. Protective Coverings of the Thecolobosa.

The *Thecolobosa* are well known as amœbæ which surround themselves with a protective case. Most are not of large size, and there are not many genera; the best known are *Difflugia* and *Arcella*, the former being commonest of all in this part of the country (East Cornwall). The exact nature of the case with which they surround themselves is not entirely clear; it appears, however, to be chiefly chitinous, never calcareous or siliceous as in Reticularia. It also appears that in one genus at least (*Difflugia*) the outer surface of the case remains sticky and moist, and thus collects sand-particles and all kinds of *débris*, which cause it to much resemble that of a caddis-worm.

It might be thought at first that here is an excellent instance of selection; the case clearly acts as a protection against enemies, and by the contained organism's sealing up its mouth by a temporary operculum, affords a safe asylum in time of drought. This is perfectly true. But the difficulty is that while the hypothesis that the case has been developed by natural selection is in itself quite workable, it does not fit in with the fact that the *Thecolobosa* are found to be living side by side with, under similar conditions to, their unprotected brethren. As I have myself observed, the bionomics of a *Difflugia* or an *Arcella* differ in no wise from those of any species of naked amœba; both classes feed on vegetable *débris* and minute Protophyta such as *chroococcacea* and diatoms; the reactions to external stimuli are similar; it is true that the shelled forms are very sluggish, but this is only to be expected. Now since the conditions of life are so similar, if the shell (which, it should be remembered, is simply a permanent exaggeration of the stiff protective cuticle that any amœba can form around itself in an unfavourable environment) has been formed by the selection of variations (no matter how caused), we should expect to find that the naked forms were either extinct or, at any rate, rare; since a shell, if necessary to a *Difflugia* for the prevention of its extinction, is equally necessary to any other kind of amœba. Instead, we find that the shelled forms are actually in a minority both in number of species, and in number of individuals.

It may, of course, be suggested that they are immigrants from the sea, where in company with the naked forms it is possible that they have been supplanted by the Reticularia; but it is impossible to understand how such a creature as a calcareous Foraminifer is any better placed than a chitinous-shelled amœba. In fact, the chief reason for the use of chalk as a building material seems to be environmental, due to the quantity of calcium compounds in sea water, and is not a point with special survival-value at all. The whole question, therefore, is, to say the least, extremely difficult of solution by any hypothesis based on the assumption of the action of natural selection.

## 2. Locomotion in Flagellata.

While many Flagellata possess only one flagellum, this number is as frequently exceeded. Thus in the group *Heteromastigoda* (which includes the well-known genera *Bodo* and *Volvox*, amongst others), the number of flagella varies from one to three. Again, some *Euglenoidea* have one long flagellum used for locomotion, and another (the paraflagellum), usually shorter, trailed behind during progression, and serving apparently as an assistant in the process of feeding; I have also seen it used, in one species, as an anchor, a sticky secretion being apparently produced which fastens its tip to any solid object handy. Finally, the groups *Tetramitina*, *Polymastigina*, and *Trepomonadina*, which lead up to the peritrichous Ciliata, have from three to eight flagella, terminal and lateral, while the remarkable connecting form *Lophomonas* (which we shall meet again later on) has a bunch of about two dozen at its anterior pole.

Here, again, selection has some material to work upon. It cannot be denied that two flagella are better than one when, as often occurs, they give their possessor the power of more rapid and powerful movement, and so enable it to more quickly remove itself from danger; the value of such powers to a small organism is quickly realised by anyone who watches a *Paramecium* feeding. Again, two flagella may make a better vortex than one, and are hence more efficient for the collection of food.

Nevertheless, the theory which bases the multiplication of the flagella on the action of natural selection breaks down on closer scrutiny. If natural selection has been the cause of the development of poly-flagellate forms, then either the mono-flagellates must be adapted to different conditions of life than those of the former group, or else the latter less efficient forms must have become extinct or nearly so. Neither statement fits the facts. The conditions of life are precisely similar in both (highly-aberrant forms like *Euglena* excepted). In both cases the food-supply consists of bacteria and particles of dead organic matter; both types are found in every conceivable environment, from a horse-pond to a rain-barrel; there is no difference whatever. As to the second eventuality, no disproof of its non-fulfilment is needed.

Indeed, it does not seem that even the premises of the argument for selection are valid. It is true that the general preponderance of activity is on the side of the poly-flagellates and that many mono-flagellates are very large compared to others of the former group (not that their size is sufficient to be of much survival-value in competition with the much larger ciliates or with the *Heliozoa* or *Tentaculifera*). But many small mono-flagellates are as active as their relatives with more flagella than one; while others of the latter class, such as *Astasia*, are more sluggish than others of equal size with only one flagellum (*e. g. Peranema*). Nor does the possession of the extra flagellum in the forms in which it is used for trophic purposes seem to have given these forms any advantage in the struggle for existence over their less well-furnished relatives, judging the case by the only admissible standard, that of preferential survival. Indeed, it is difficult to see how it could, since at present the food-supply is quite plentiful enough for all, and there is no reason to believe that it has been otherwise since very ancient times; bacteria and decaying vegetable matter were probably abundant in the Palæozoic seas. In this case too, therefore, we seem to be driven to admit that natural selection is not competent to explain the facts.

### 3. Evolution of the Ciliata.

The history of this step in evolution, like that of the one just discussed, is one of the further perfecting of what may be termed the "tropho-motor system"; that is, of the system of cell-organs concerned with feeding and movement. The general lines of development seem fairly clear. The ancestor of the Ciliates must have been Flagellates related to the existing *Tetramitina*. It probably possessed several flagella placed anteriorly, and was somewhat pear-shaped. The flagella seem to have multiplied by antimeric fission in such a way as to become arranged more or less around the mouth; at the same time they probably became shorter and stiffer, since a number of long flexible flagella would become entangled and neutralise each other's efforts. It then must have much resembled the existing *Lophomonas*, a linking form for whose preservation biologists have to thank that somewhat objectionable insect, the cockroach, of which it is a parasite. Further progress consisted in the increased shortening of the flagella to the condition of short rods, and the reduction of their "musculature" to a contractile strip on one side, which, in conjunction with an elastic strip on the other side, caused a rhythmic sweep instead of the sinuous flexion of a flagellum. The organism was now a Ciliate, and must have borne a close resemblance to the very primitive peritrichous form *Strombidium*.

Such probably was the process. In favour of the view that selection was here the guiding force, it may be argued that all the connecting links have disappeared, save one which has been driven (presumably) to parasitism. This is true; but we are faced with the same overwhelming difficulty as before. The Ciliata are descended from flagellates, and have acquired in the process a tropho-motor apparatus vastly superior to that of their ancestors. They live side by side with flagellates, under precisely similar conditions, with precisely similar reactions to the ordinary stimuli of the environment; their food is similar; practically the sole bionomic difference is that the larger ciliates can ingest much more at once (which would indeed make for an even more speedy extinction of the much smaller flagellates). Everything seems to point to the conclusion that the higher types should have supplanted the lower simply in virtue of increased size and activity, and yet nothing of the kind has occurred. If development had in this instance been due to the selection of the in every way more "fit" ciliates, the flagellates as a class should be extinct, or at most confined to a few struggling groups; instead they are ubiquitous and racially vigorous. These facts, surely, absolutely preclude the ascription of the developmental process in this case to natural selection.

## 4. Size in Ciliata.

This is, as is well known, very variable in the different forms. For example, a species of *Halteria* is about 1–1000th in. long; at the other end of the scale are forms like *Trachelius* easily visible to the unassisted eye. The two very common genera, *Paramecium* and *Stylonychia*, both reach a maximum size of about 1–70th in. The widely-diffused *Coleps* is 1–500th in. in length; *Spirostomum* is said to be sometimes as much as 1–10th of an inch. (Personally, I have never found quite such large specimens.) Speaking generally, the peritrichous forms do not contain individuals of very large size, 1–200th in. being a fair average; *Stentor*, however, forms a notable exception. The other groups give us a mixed multitude of all sizes; the maximum is reached in the *Heterotricha* (*Kondylostoma*, *Bursaria*, *Spirostomum*) and the *Holotricha* (*Trachelius*, *Amphileptus*).

There can be no doubt that large size is a feature with survival-value, provided it is not carried to excess. In a single cell possibilities are of course limited by the necessity of keeping the ratio of surface to volume sufficient to allow of free diffusion of oxygen in, and carbon-dioxide and other excretions out; the development of the system of the contractile vacuole to the extent it attains in some large forms (*e.g. Amphileptus*) is possibly concerned with this necessity. But even so, a large range of variation is possible. The advantage of large size in a Protozoon is obvious to the practical biologist; *Coleps* is swept away by a current which *Paramecium* breasts without difficulty, *Euplotes* is captured by the Heliozoon from which *Bursaria* escapes. But, more independent and "fit" though the large forms are, they have not attained their high estate by the gradual extinction of smaller types. Both are equally vigorous. Indeed, it is the same throughout the whole phylum; the extremely minute and the relatively gigantic, *Bodo* and *Trachelius*, rub shoulders, so to speak, in every environment. Natural selection fails here, as before, in the explanation of the facts of biology.

### 5. SPRINGING ORGANS OF HALTERIA.

This genus, the typical one of the family *Halteridæ*, is distinguished by the possession, in addition to its ciliary ring, of an array of stiff spines, varying in number in different species. These spines are prolongations of the cuticle, and are movable on their bases by contraction of the myophane layer immediately underneath the cuticle. By sudden movement of the spines the organism can leap a good distance.

The value of such an apparatus, in facilitating escape from enemies, is obvious. Its sensitivity is very high; a mere touch of the tripod of the microscope, a current hardly visible, the touch of a spine on a bit of *débris*, is sufficient to cause a violent leap. But such structures as leaping spines would, if necessary for the survival of one form, be equally necessary for that of others of the same size and habits. If natural selection has acted here, should we not find in *Coleps, Urocentrum, Enchelys*, and the like, either similar structures or else others fulfilling similar ends? Should we not expect that all these forms, which need protection from enemies in just the same measure as *Halteria*, should otherwise have become extinct, or nearly so? But that this has not occurred our microscopes tell us. How then can selection have played any part in the evolution of *Halteria's* spines?

### 6. TROPHIC CILIA OF BURSARIA.

This genus is characterised, among other points, by the possession in the vestibule of a series of short, very stout cilia arranged in regular rows, which work to and fro in unison and act as a very efficient trophic apparatus.

Now in essence these trophic cilia are simply an instance of the extreme development of the larger oral cilia found in all *Heterotricha*. In this genus they have reached a very high stage of development, forming an extremely efficient apparatus. The differences between the two kinds are, indeed, not overwhelmingly great, yet the trophic cilia of *Bursaria* have all the appearance of being due to real adaptive modification. But there can be no question that natural selection has played no part in their development, since the other species of similar habits are without them.

### 7. SETOSE PROCESSES IN EUPLOTES AND RELATED GENERA.

These are well marked, stiff, limb-like processes of a different nature to the trophic cilia of *Bursaria*. They serve as locomotor organs, and have a powerful system of muscular fibrils developed around their roots. By the energetic contractions of these the organism is propelled with a running motion with great velocity.

Considered as locomotor organs, they are far more efficient than the ciliary ring or coat. Indeed, in the most highly-developed forms like *Euplotes* the cilia have vanished, superseded by the styles and setæ. A progressive differentiation, too, can be detected in the *Hypotricha*, from forms without setæ to forms in which they are the only tropho-motor organs. We appear, therefore, to have here again an instance of progression towards greater efficiency, and this entirely independent of natural selection, since there is no sign of extinction of the less well-provided types, whether among the other *Hypotricha* or in any other group.

Examples might be multiplied almost indefinitely, did space permit. But perhaps sufficient has been said to form an outline of the question under discussion—an outline admittedly sketchy and suffering from over-compression. The gaps necessarily left in the arguments and examples many readers will be able to fill in for themselves.

Although this paper is of intention critical, yet it would be hardly fair not to give some idea of what forces may have been at work to produce the results described.

A factor which suggests itself at once is that of the inheritance of characters acquired by use. Thus the development of spines in *Halteria* might be explained as due to the exercise of rudimentary spines producing their greater development in the individual, and as a result a modification of the germ-plasm in the same direction. But since experiment has shown, I believe conclusively, that somatic modifications are not transmissible even in unicellular forms, this hypothesis breaks down; though Lloyd Morgan's theory, that acquired characters may favour the propagation of mutations in the same direction, is important in this connection.

Probably the best explanation is to be found in some form of the orthogenesis theory, of continual progress in a straight line. A germinal mutation caused by change in the environment (in the broad sense of the term) produces change in the cytoplasm, and this change forms a kind of groove along which more mutations in the same direction accumulate.

To many a physico-chemical statement of such a process would be all-sufficient; but to others, myself among the number, such a statement seems only to give us an idea of the steps of the process, not one of the process as a whole. The problem of organic evolution lies deeper still. How can a mechanical statement of the orthogenesis theory explain, say, the marvellous correlation of variation manifested in the evolution of the vertebrate eye? As I say, the riddle's solution lies deeper. Each step in variation is physico-chemical, but variation itself is essentially the expression of the free creativeness of Life, of that "new form of energy" which inhabits protoplasm.

# NOTES AND QUERIES.

## MAMMALIA.

**Grey Squirrel in Northamptonshire.**—I have seen a Grey Squirrel which was shot about December 30th, 1915, at Weston, near Towcester, Northamptonshire. This is sixteen miles N.W. of Whaddon, where I saw one the previous May; and as it is less than five miles from the Oxfordshire border, I suppose we shall get this undesirable in the county before long.—O. V. Aplin (Bloxham, Oxon).

**Do Rats Eat the Eggs of Poultry?**—It is a very common belief that Rats will remove the eggs from the nests of Poultry and eat them, and one can get plenty of book and verbal evidence of the ways and means by which the eggs are removed, and that egg-sucking by Rats is very frequent. And yet in no single instance have I been able to obtain information that is satisfactory and not hearsay, and I have often questioned farmers and poultry-keepers on this point, but in vain; and I have never known an instance in years of personal experience in keeping poultry. That the habits of these vermin may vary in different localities is quite possible, and I should be glad of any satisfactory proof upon this question. That Rats do destroy Chickens and Ducklings, etc., I am only too well aware.—J. Steele Elliott.

## AVES.

**Reported Nesting of the Gannet in Orkney.**—In the 'Zoologist' for last year (p. 433) I published the report of a pair of Gannets nesting on the Horse of Copinsay in 1911 (not 1914 as printed). I am now sorry to say that further inquiries have thrown some doubt on the statement, which seemed reliable at the time. I am informed that in an Orkney newspaper in that year the fact was noticed that one pair had nested for the first time. But another resident, living on that side of Orkney, who has been in the habit of visiting the birdcliffs of Copinsay for many years, in answer to my inquiries writes as follows: "No Solans ever laid on the Horse of Copinsay, but half a mile away is the island of Copinsay, with about three-quarters of a mile of cliffs, averaging 200 ft. in height, where tens of thousands of birds (*i. e.* other rock-birds) lay. Some fifty years ago it was believed that Solans hatched there, but no correct evidence could be gathered now as the men are dead who lived there then." About 1907 or 1908 a pair of Solans lived about the cliffs for a short time during the nesting season, and a fisherman (passing there) told my correspondent he believed they were building. But nothing came of it, as no egg or young was seen. In fact, the birds disappeared before they had time to bring out a young one. My original informant is only able to repeat that it was stated at the time that one pair were nesting in 1911, though he does not seem clear as to whether it was on Copinsay or the Horse of Copinsay. He adds that it would have been very unlikely if the pair had got off its egg, as Copinsay is the only place in Orkney where the eggs of sea-birds are taken in large quantities. Here I must leave it; but it seems probable that about that year, at all events, a pair of Gannets contemplated nesting there, if they did not actually do so.—O. V. APLIN.

**Snowy Owl in Bucks.**—Intending to give the bird three or four weeks' law before making its presence known, I have inadvertently neglected to publish the occurrence for as many years. As, however, a visit from the species is rare throughout England, and unique so far as this county (Bucks) is concerned, a record of the fact is better late than never. On the afternoon of July 31st, 1912, while excavating a large and prolific Romano-British "Villa" on Yewden Manor in this parish (Hambleden), on Lord Hambleden's Greenlands estate, upwards of 400 yards north of Hambleden lock on the Thames, I overheard one of the labourers calling his mate's attention to a large white Owl sitting in one of a row of sycamore trees in the hedge dividing the field we were working in from the road running northwards. Hardly had he spoken, before, with characteristic plunge, followed by throw-up into the air, a Snowy Owl flew out, and came in our direction. As it approached it began to croak hoarsely (well described by Dresser, 'Manual of Pal. Birds,' as "a loud *krau-krau*"), and presently wavering in its choice of direction, it "trod air," and then turned round; but shortly deciding on its old course, it once more turned round, and again proceeded westwards, passing me at a distance I estimated at less than 80 yards. It continued to fly straight in that direction until I lost sight of it over and behind a group of large trees surrounding a pond known as "The Baths," which I believe to be of Roman origin or development, a quarter of a mile from the spot where I was standing. It was also seen by my overseer, Dr.

A. E. Peake, M.B.; by some eleven labourers; and by, I think, a few visitors who happened to be at the excavations at the moment. On August 2nd it was seen near Pheasants' Hill, also in Hambleden parish, but on the opposite (*i. e.* N.E.) side of the village, by a son of Mr. Louis Deane, who, unfortunately, was soon afterwards taken with a serious illness, which eventually terminated fatally, without my obtaining further details. Two or three days later Mr. Deane himself saw the bird in the same direction, and "was within eight or ten yards of it, and it flew broadside of" him. I am absolutely sure of the bird's identity, and it is a species for which nothing else is likely to be mistaken. Independently of the undoubted size, the croaking at once puts the Barn-Owl out of court, which seems the only bird which could under any possible circumstances be taken for it. Especially having regard to the time of year, it seems very much more likely that the bird was an escape from an aviary than a visitor under more natural conditions, but I failed to hear of any such loss; neither, so far as I am aware, was the bird reported from any other parish either before or after its sojourn in this one. A Snowy Owl seen flying at a little distance generally appears very white, so that although this bird looked white enough for an adult male, I cannot speak with certainty on this point.—ALFRED HENEAGE COCKS (Poynetts, Skirmett, near Henley-on-Thames).

**Early Autumnal Movements of Sandpipers, Ring-Plover, etc., in Bedfordshire.**—Whilst walking around the Bedford Sewage Farm at Newnham, on July 15th last, the following species were observed: four Common Sandpiper, two Green Sandpiper, one adult and one young Ring-Plover, a "wisp" of six Snipe, and three Redshank, the latter being probably local breeding birds that nest in this locality. The occurrences of the three first-named birds are the earliest autumnal records I have of these species for that county.

The Common Sandpiper (*Totanus hypoleucus*) break their migratory journeys in the spring and autumn quite commonly, appearing generally at the latter end of April and early May; but I have records as early as April 7th, 1894, Cardington, and April 13th, 1903, Biggleswade, and as late as June 6th, 1903, Great Barford, June 8th, 1896, Turvey; their return migration taking place generally during August or early September, early records other than the present year being July 16th, 1905, Bletsoe, and July 24th, 1908, Cardington; and as late as September 13th, 1853, Biggleswade, and September 15th, 1902, Newnham.

The Green Sandpiper (*Totanus ochropus*) is very frequently observed during the autumn migration at the end of July and August, and on such favourite feeding haunts as at Newnham many may often be seen in company together; there does not seem to be a similar return journey in the spring when the Green Sandpiper can be looked for with any certainty, but at all other times it might be described as an erratic migrant, and, although not breeding in the British Islands, it has been met with in this county, as the following notes show, practically in every month of the year.

January.—31, 1855, Broom.

February.—No actual records can be given, but without a doubt this blank could be easily filled.

March.—10, 1905, three, Newnham; 29, 1897, Biggleswade.

April.—7, 1913, Willington.

May.—Once observed at Biggleswade by the late Mr. J. King, but no actual date was given to me by him.

June.—Mr. A. Covington, the local taxidermist, assures me it has once been obtained during this month.

July.—15, 1916, two; 27, 1901, one; 31, 1900, eight, all at Newnham.

August.—Solitary records during this month are far too numerous to narrate; 1, 1903, five; 9, 1899, fifteen, Newnham; 30, 1900, five at Moat Close, Elstow; 31, 1900, eight, Newnham.

September.—4, 1902, Newnham; 8, 1904, Goldington; 11, 1857, Biggleswade; 13, 1914, Blunham; 22, 1912, two, Newnham.

October.—16, 1904, Fenlake; 19, 1914, Millbrook.

November.—14, 1915, Cardington; 15, 1894, Pertenhall; 20, 1914, Renhold; 29, 1913, Ampthill.

December.—1, 1854, Broom; 19, 1860, Biggleswade; 23, 1900, Renhold; 26, 1894, Fenlake.

Ring-Plover (*Ægialitis hiaticula*).—Until a year or so longer when the old-fashioned methods of sewage disposal cease and the partly flooded arable fields still remain at Newnham, the Ring-Plover will no doubt continue to be observed regularly in that locality during the spring and autumn movements, and not infrequently at other times of the year also. In any other part of the county it has always been of rare occurrence, although I have known, from hearing their frequent calling overhead at night, that considerable numbers must on migration pass over this county. The largest parties of which I have notes are as follows:—In the autumn of 1878, seven were taken to the local taxidermist in one week; May 26th, 1898, six were seen together; August 18th, 1902, a flock of about twelve; April 27th, 1905, four; March 26th, 1916, a flock of nine in company with a similar number of Dunlin. All these records are from Newnham. The majority of these notes are personal observations and from intermittent visits to that county; they must not be taken for careful and continued records. The results of such would be invaluable, especially from Newnham, for any future reference to migration in relation to Bedfordshire.—J. Steele Elliott.

**Behaviour of two Young Cuckoos in one Nest.**—On May 24th last I found the nest of a Meadow-Pipit on Baildon Moor, with three eggs and one Cuckoo's egg; near the same place last year a naturalist friend of mine found a similar nest containing one Cuckoo's egg, and on May 30th I found another Titlark's nest containing four eggs, one of which was a Cuckoo's. This was built in a pasture adjoining the moor, and separated by a distance of perhaps a quarter of a mile. The Cuckoos' eggs were evidently laid by different females, as the eggs were quite different in size, shape, and, in a lesser degree, coloration. On June 2nd a naturalist friend of mine from Bournemouth visited both the above nests in the morning, and in each nest the Cuckoo's egg had hatched, but the three eggs in each Pipit's nest were still unhatched. After inspecting the nests my friend and I had a long walk, and on returning in the afternoon, I found that one of the eggs in the nest on the moor had hatched, but the other eggs in the nest in the pasture were still unhatched. It was quite evident that the Cuckoos in the above nests were hatched within at most an hour or two of each other, and could not have been many hours old when we visited the nests on June 2nd. My friend and I again visited the nests on June 3rd, at about 9.30 a.m., and found that the nest on the moor contained one young Pipit and Cuckoo, and one egg of Pipit was thrown out and was on the rim of the nest, so another egg had been thrown out, or a young Pipit; but I could find no trace of either near the nest. Probably the young Pipit which was hatched on June 2nd had been thrown out by the Cuckoo. The nest in the pasture contained the young Cuckoo and two eggs of the Pipit, and another egg was lying on the rim of the nest, having evidently been thrown out by the Cuckoo. We had not long to wait before the Cuckoo began to be very restless, and in a short time it heaved the egg of the Pipit to the top of the nest by pushing the egg up the side of it, not balancing the egg in the hollow of its back as it sometimes does, soon after which operation it hoisted a young Pipit out of the nest. Afterwards my friend and I decided to place all the unhatched eggs in the nest on the moor, and place the two young Cuckoos in the nest built in the pasture; by this arrangement we thought we should save a few Pipits' lives; but alas for human interference in matters of this nature! After carrying out this arrangement I accompanied my friend part of the way to his lodgings, which were at Baildon, and returned to the nests; in that which contained the young Cuckoos, one had been thrown out by the other, and in trying to get back into the nest it had got its leg fast in some mat-grass, but its head was hanging down into the nest. After extrication from the grass it fell forward into the nest again. At this point I left for some refreshment at a farm near by, and on my return both Cuckoos were still in the nest; the weather being very cold at the time, and I find young Cuckoos when associated with other nestlings are much more restless in warm than cold weather. However, fortunately, again I had not long to wait before Greek was pitted against Greek, and one would hoist the other to the top of the nest, but when the feat was within an ace of accomplishment, be defeated by the other grasping the top of the nest with both feet, the result being that both birds toppled again to the bottom of the nest. This process of hoisting each other from the nest continued until I left in the afternoon. Before leaving the moor I visited the nest of the Pipit to which my friend and I had committed the charge of eggs and young in the morning, but, strange to say, the Pipit was sitting on an empty nest, and the young Pipits were lying dead outside the nest; the eggs I could not find anywhere. Thus my confidence that the Pipits would hatch and rear the introduced eggs and young of its own species was sadly misplaced. I again visited the nest containing the young Cuckoos on June 4th and got there at 10.30 a.m., to find both Cuckoos outside the nest struggling together, their legs and wings being interlocked octopus-like. The weather at this time was very cold and even wretched for the time of year, and I quickly put both Cuckoos back into the nest, and had an hour's walk on the moor, the weather in the meantime getting worse, rain having set in, so I returned to the nest and found that one of the Cuckoos had again been thrown out of the nest, and owing to the cold weather was in a very torpid condition.

If the weather had been warm like the corresponding period last year, by frequently putting back the Cuckoo again into the nest when thrown out, I had hoped after about the fourth day that both Cuckoos would settle down and live afterwards contentedly; but in the circumstances I decided to leave one only in the nest and try to keep the other alive two or three days, and introduce it again into the nest, if successful in keeping it alive for this period, and in this I expected little difficulty, since I had reared the Cuckoo formerly without any difficulty whatever; but in the present case my hope was doomed to disappointment, for the bird died on the morning of June 6th, from lack, not so much, I believe, of suitable food, as of the proper amount of heat. It was only about two days old when it was brought home.

Adjoining Baildon Moor is a wood which is a famous rendezvous for Cuckoos, and although I found about eight nests of Titlarks with four eggs in each nest within a short distance from those containing Cuckoo's eggs alluded to above, yet in no other nest was there to be found a Cuckoo's egg, which is somewhat remarkable if Cuckoos lay as many eggs as is sometimes alleged. I may add that all the Titlarks' eggs contained in the above nests were laid subsequently to those I found in the nests of Titlarks on May 24th and 30th, and these could not all be unsuitable hosts for Cuckoos' eggs; and if Cuckoos do not abstract one egg from the nests of the dupes at or about the time of the introduction of their eggs, how have we to account for three eggs only in the nests of those I found, and four eggs in all the other nests not containing Cuckoo's eggs?—E. P. Butterfield (Wilsden, Bradford).

## CHÆTOPODA.

**A Note on the Behaviour of Nereis fucata.**—On p. 238 of the present volume of the 'Zoologist' I described the escape of a *Nereis fucata* (which was about 3 in. in length) from the jaws of two Hermit-Crabs, and mentioned that the worm retreated beneath the pebbles on the floor of the aquarium. A few days after this incident the Hermit-Crabs were removed from the tank. The tank remained empty for nearly three weeks, and during this time I did not see the worm, which I supposed to be dead. Several newly-captured Hermit-Crabs and a commensal Sea-Anemone (*Sagartia parasitica*) were now placed in the aquarium, and soon afterwards (within a quarter of an hour) the *Nereis* made its appearance from beneath the pebbles. It moved rapidly to and fro upon the floor of the aquarium, and then, forcing its way under the whelk-shell of one of the Hermit-Crabs, tried to enter the shell beneath the body of the crustacean. The Hermit-Crab jerked its body in and out of the shell in such a way as either to prevent or deter the worm from gaining an entry, and then scuttled away, leaving the worm on the floor. The *Nereis* now re-entered the pebbles, and I saw nothing of it for two days. On the third morning I removed a half-digested mass which was encumbering the disc of the Sea-Anemone (the diameter of whose circle of extended tentacles was about 1½ in.), and discovered that this mass was the remains of the *Nereis*. These facts seem worthy of record because the meaning of the association between the worm and the Hermit-Crab is only partly understood; indeed, the whole subject of the association of *Eupagurus bernhardus*, *Sagartia parasitica*, and *Nereis fucata* stands in need of fresh and intensive study.—H. N. MILLIGAN.

## ASTEROIDEA.

**Rate of Locomotion in Sun-Stars.**—The usual rate of locomotion of the common Sun-Star (*Solaster papposus*) is not high. In a note published in the 'Zoologist' of 1915 (pp. 437-438), it was remarked that the average in a Sun-Star of 2 inches in diameter was 1 inch in 26·1 seconds; and subsequent observations have shown this to be approximately the rate of locomotion of other examples of about the same size. When occasion arises, however, a Sun-Star can travel at a much greater speed. Several of the captive Sun-Stars observed by me have had a peculiar habit (most marked in animals new to the aquarium) of moving upon food (say a piece of fresh Sea-Urchin, Crab, Shrimp, or Fish) placed close to them, then partially assuming the usual feeding attitude, and finally quitting the food very suddenly and retreating at a speed which I have not seen them attain under any other circumstances. (I do not know the cause of this behaviour.) I determined to ascertain as exactly as possible the speed of a Sun-Star when thus retreating, and I was able to do this in the case of an individual of 2½ inches in diameter. The Sun-Star (which had been in the aquarium for ten days) retreated from a piece of recently-killed Sea-Urchin, and three separate records were secured in its succeeding wild career in the tank. It travelled in a horizontal direction upon the rough vertical rockwork which forms the back of the tank for a distance of approximately 10 inches in 30 seconds; it moved across the fine gravel on the floor of the tank for 7 inches in 30 seconds, and it climbed up the glass front of the aquarium for 3¾ inches in 30 seconds. It will be noticed that the Sun-Star was a small one. Large examples, say of 6 or 8 inches in diameter, seem always to creep very slowly, at all events in an aquarium.—H. N. MILLIGAN.

# NOTICES OF NEW BOOKS, ETC.

*British Birds.* Vol. III. By A. Thorburn, F.Z.S. London: Longmans, Green & Co. 1916. £1 11*s.* 6*d.* net. Set of 4 vols. £6 6*s.* net.

Beautiful as were the first two volumes of this delightful work, the present one far surpasses the two combined, and in it the pictures worthy to be framed may be numbered by the dozen. This is, of course, what might have been expected, for the *Anatidæ*, now dealt with, are those among our birds which are most adapted for pictorial treatment, not only by their beauty of form and colouring, but, as has been remarked by other reviewers, by their gregarious habits, which render group-pictures of them more natural than is the case with most other birds. In addition to this group Mr. Thorburn undertakes in this volume the Spoonbill, Ibis, Flamingo, Storks, Sand-Grouse, Pigeons, Game-birds, and Rails, finishes the Herons, and figures the great Bustard as a frontispiece, the letterpress dealing with it closing the volume. He is thus well off for picturesque subjects outside the *Anatidæ*, and generally rises to the occasion; his concluding plate of Herons is a gem, though that showing the Storks and Flamingo is not nearly so good, the former birds being too rounded and short, with the hind toes far too small, and the latter too hard in outline and lacking the slim grace and looseness of plumage so characteristic of the species. Among the Ducks, the plate of the Mergansers is easily the best, and the diving species generally are better than the rest; the Sheldrakes are disappointing, their poses not being very characteristic, while, though full justice is done to the exquisite plumage of the Common Teal and Garganey, the Blue-winged Teal and American Wigeon are less happily rendered as regards their equally delicate colouring. Among the Swans, sufficient stress is not laid on the difference in size between the Whooper and Bewick's, nor does the plate of those Geese distinguish enough between the flat snaky head of the Brent and the rounder one of the Bernicle. The letterpress calls for no especial criticism; but we note some regrettable misprints, "*Mareco*" and "*Mereca*" for *Mareca*, on pp. 38 and 39; "Bartlet" for Bartlett on the latter; and "*arbellus*" for *albellus*, twenty pages further on.

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